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A MECHANISTIC VIEW OF PSYCHOLOGY[1]

TRADITIONAL religion, traditional medicine and traditional psychology have insisted upon the existence in man of a triune nature. Three "ologies" have been developed for the study of each nature as a separate entity—body, soul and spirit; physiology, psychology, theology; physician, psychologist, priest. To the great minds of each class, from the days of Aristotle and Hippocrates on, there have come glimmerings of the truth that the phenomena studied under these divisions were interrelated. Always, however, the conflict between the votaries of these sciences has been sharp, and the boundary lines between them have been constantly changing. Since the great discoveries of Darwin, the zoologist, biologist and physiologist have joined hands, but still the soul-body-spirit chaos has remained. The physician has endeavored to fight the gross maladies which have been the result of disordered conduct; the psychologist has reasoned and experimented to find the laws governing conduct; and the priest has endeavored by appeals to an unknown god to reform conduct.

The great impulse to a deeper and keener study of man's relation, not only to man, but to the whole animal creation, which was given by Darwin, has opened the way to the study of man on a different basis. Psychologists, physicians and priests are now joining hands as never before in the great world-wide movement for the betterment of man. The new sci-

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ence of sociology is combining the functions of all three, for priest, physician and psychologist have come to see that man is in large measure the product of his environment.

My thesis to-night, however, will go beyond this common agreement, for I shall maintain, not that man is in *large measure* the product of his environment, but that environment has been the actual *creator* of man; that the old division between body, soul and spirit is non-existent; that man is a unified mechanism responding in every part to the adequate stimuli given it from without by the environment of the present and from within by the environment of the past, the record of which is stored in part in cells throughout the mechanism, but especially in its central battery—the brain. I postulate further that the human body mechanism is equipped first for such conflict with environment as will tend to the preservation of the individual and second for the propagation of the species, both of these functions when most efficiently carried out tending to the upbuilding and perfection of the race.

Through the long ages of evolution the human mechanism has been slowly developed by the constant changes and growth of its parts which have resulted from its continual adaptation to its environment. In some animals the protection from too rough contact with surroundings was secured by the development of an outside armor; in others noxious secretions served the purposes of defense, but such devices as these were not suitable for the higher animals or for the diverse and important functions of the human race. The safety of the higher animals and of man had to be preserved by some mechanism by means of which they could become adapted to a much wider and more complex environment, the dominance over which alone gives them their right to be called "superior beings." The mechanism by the progressive development of which living beings have been able to react more and more effectually to their environment is the central nervous system, which is seen in one of its simplest forms in motor plants, such as the sensitive plant and the Venus fly trap, and in its highest development only in the sanest, healthiest, happiest and most useful men.

The essential function of the nervous system was primarily to secure some form of motor activity, first as a means of securing food, and later as a means of escaping from enemies and to promote procreation. Activities for the preservation of the individual and of the species were and are the only purposes for which the body energy is expended. The central nervous system has accordingly been developed for the purpose of securing such motor activities as will best adapt the individuals of a species for their self-preservative conflict with environment.

It is easy to appreciate that the simplest expressions of nerve response—the reflexes—are motor in character, but it is difficult to understand how such intangible reactions as love, hate, poetic fancy, or moral inhibition can be also the result of the adaptation to environment of a distinctively motor mechanism. We expect, however, to prove that so-called "psychic" states as well as the reflexes are products of adaptation; that they occur automatically in response to adequate stimuli in the environment; that like the reflexes they are expressions of motor activity, which, although intangible and unseen, in turn incites to activity the units of the motor mechanism of the body; and finally, that any "psychic" condition results in a definite depletion of the potential energy in the brain cells which is proportionate to

the muscular exertion of which it is the representative.

That this nerve mechanism may effectively carry out its twofold function, first, of self-adaptation to meet adequately the increasingly complicated stimuli of environment; and second, of in turn adapting the motor mechanism to respond adequately to its demands, there have been implanted in the body numerous nerve ceptors—some for the transmission of stimuli harmful to the mechanism—nociceptors; some of a beneficial character—beneceptors; and still others more highly specialized, which partake of the nature of both bene- and nociceptors—the distance ceptors, or special senses.

A convincing proof that environment has been the creator of man is seen in the absolute adaptation of the nociceptors as manifested in their specific response to adequate stimuli, and in their presence in those parts of the body only which throughout the history of the race have been most exposed to harmful contacts. We find they are most numerous in the face, the neck, the abdomen, the hands and the feet; while in the back they are few in number, and within the bony cavities they are lacking.

Instances of the specific responses made by the nociceptors might be multiplied indefinitely. Sneezing, for example, is a specific response made by the motor mechanism to stimulation of the nociceptors in the nose, while stimulation of the larynx does not produce a sneeze, but a cough; stimulation of the nociceptors of the stomach does not produce cough, but vomiting; stimulation of the nociceptors of the intestine does not produce vomiting, but increased peristaltic action. There are no nociceptors misplaced; none wasted; none that do not make an adequate response to adequate stimulation.

Another most significant proof that the environment of the past has been the creator of the man of to-day is seen in the fact that man has added to his environment certain factors to which adaptation has not as yet been made. For example, heat is a stimulus which has existed since the days of prehistoric man, while the X-ray is a discovery of to-day; to heat the nociceptors produce an adequate response; to the X-ray there is no response. There was no weapon in the prehistoric ages which could move at the speed of a bullet from the modern rifle; therefore, while slow penetration of the tissues produces great pain and muscular response, there is no response to the swiftly moving bullet.

The response to contact stimuli then depends always on the presence of nociceptors in the affected part of the body and to the type of the contact. Powerful response is made to crushing injury by environmental forces; to such injuring contacts as resemble the impacts of fighting; to such tearing injuries as resemble those made by teeth and claws. On the other hand, the sharp division of tissue by cutting produces no adaptive response; indeed, one might imagine that the body could be cut to pieces by a superlatively sharp knife applied at tremendous speed without material adaptive response.

These examples indicate how the history of the phylogenetic experiences of the human race may be learned by a study of the position and the action of the nociceptors just as truly as the study of the arrangement and variations in the strata of the earth's crust discloses to us geologic history.

These adaptive responses to stimuli are the result of the action of the brain cells which are thus continually played upon by the stimuli of environment. The energy stored in the brain cells in turn activates the various organs and parts of the body.

If the environmental impacts are repeated with such frequency that the brain cells have no time for restoration between them, the energy of the cells becomes exhausted and a condition of shock results. Every action of the body may thus be analyzed into a stimulation of ceptors, a consequent discharge of brain cell energy, and a final adaptive activation of the appropriate part. Walking, running and their modifications constitute an adaptation of wonderful perfection, for, as Sherrington has shown, the adaptation of locomotion consists of a series of reflexes—ceptors in the joints, in the limb and in the foot being stimulated by variations in pressure.

As we have shown, the bene- and nociceptors orientate man to all forms of physical contact—the former *guide him to* the acquisition of food and to sexual contact; the latter *direct him from* contacts of a harmful nature. The distance ceptors, on the other hand, adapt man to his distant environment by means of communication through unseen forces—ethereal vibrations produce sight; air waves produce sound; microscopical particles of matter produce smell. The advantage of the distance ceptors is that they allow time for orientation, and because of this great advantage the majority of man's actions are responses to their adequate stimuli. As Sherrington has stated, the greater part of the brain has been developed by means of stimuli received through the special senses, especially through the light ceptors, the optic nerves.

We have just stated that by means of the distance ceptors animals and man orientate themselves to their distant environment. As a result of the stimulation of the special senses chase and escape are effected, fight is conducted, food is secured, and mates are found. It is obvious, therefore, that the distance ceptors are the primary cause of continuous and exhausting expenditures of energy. On the other hand, stimuli applied to contact ceptors lead to short, quick discharges of nervous energy. The child puts his hand in the fire and there is an immediate and complete response to the injuring contact; he sees a pot of jam on the pantry shelf and a long train of continued activities are set in motion, leading to the acquisition of the desired object.

The contact ceptors do not at all promote the expenditure of energy in the chase or in fight, in the search for food or for mates. Since the distance ceptors control these activities, one would expect to find that they control also those organs whose function is the production of energizing internal secretions. Over these organs—the thyroid, the adrenals, the hypophysis—the contact ceptors have no control. Prolonged laboratory experimentation seems to prove this postulate. According to our observations, no amount of physical trauma inflicted upon animals will cause hyperthyroidism or increased epinephrin in the blood, while fear and rage do produce hyperthyroidism and increased epinephrin. This is a statement of far-reaching importance and is the key to an explanation of many chronic diseases—diseases which are associated with the intense stimulation of the distance ceptors in human relations.

Stimuli of the contact ceptors differ from stimuli of the distance ceptors in still another important particular. The adequacy of stimuli of the contact ceptors depends upon their number and intensity, while the adequacy of the stimuli of the distance ceptors depends upon the *experience* of the species and of the individual. That is, according to phylogeny and ontogeny this or that sound, this or that smell, this or that sight, through associa-

tion recapitulates the experience of the species and of the individual—awakens the phylogenetic and ontogenetic memory. In other words, sights, sounds and odors are symbols which awaken phylogenetic association. If a species has become adapted to make a specific response to a certain object, then that response will occur automatically in an individual of that species when he hears, sees or smells that object. Suppose for example, that the shadow of a hawk falls simultaneously on the eyes of a bird, a rabbit, a cow and a boy. That shadow would at once activate the rabbit and the bird to an endeavor to escape, each in a specific manner according to its phylogenetic adaptation; the cow would be indifferent and neutral; while the boy, according to his personal experience or ontogeny, might remain neutral, might watch the flight of the hawk with interest or might try to shoot it.

Each phylogenetic and each ontogenetic experience develops its own mechanism of adaptation in the brain; and the brain threshold is raised or lowered to stimuli by the strength and frequency of repetition of the experience. Thus through the innumerable symbols supplied by environment the distance ceptors drive this or that animal according to the type of brain pattern and the particular state of threshold which has been developed in that animal by its phylogenetic and ontogenetic experiences. The brain pattern depends upon his phylogeny, the state of threshold upon his ontogeny. Each *brain pattern* is created by some particular element in the environment to which an adaptation has been made for the good of the species. The *state of threshold* depends upon the effect made upon the individual by his personal contacts with that particular element in his environment. The presence of that element produces in the individual an associative recall of the adaptation of his species—that is, the brain pattern developed by his phylogeny becomes energized to make a specific response. The intensity of the response depends upon the state of threshold—that is, upon the associative recall of the individual's own experience—his ontogeny.

If the full history of the species and of the individual could be known in every detail, then every detail of that individual's conduct in health and disease could be predicted. Reaction to environment is the basis of conduct, of moral standards, of manners and conventions, of work and play, of love and hate, of protection and murder, of governing and being governed, in fact, of all the reactions between human beings—of the entire web of life. To quote Sherrington once more: "Environment drives the brain, the brain drives the various organs of the body."

By what means are these adaptations made; what is the mechanism through which adequate responses are made to the stimuli received by the ceptors? We postulate that in the brain there are innumerable patterns each the mechanism for the performance of a single kind of action, and that the brain cells supply the energy—electric or otherwise—by which the act is performed; that the energy stored in the brain cells is in some unknown manner released by the force which activates the brain pattern; and that through an unknown property of these brain patterns each stimulus causes such a change that the next stimulus of the same kind passes with greater facility.

Each separate motor action presumably has its own mechanism—brain pattern—which is activated by but one ceptor and by that ceptor only when physical force of a certain intensity and rate of motion is applied. This is true both of the visible

contacts affecting the nociceptors and of the invisible contacts by those intangible forces which affect the distance ceptors. For example, each variation in speed of the light-producing waves of ether causes a specific reaction in the brain. For one speed of ether waves the reaction is the perception of the color blue; for another, yellow; for another, violet. Changes in the speed of air waves meet with specific response in the brain patterns tuned to receive impressions through the aural nerves, and so we distinguish differences in sound pitch. If we can realize the infinite delicacy of the mechanisms adapted to these infinitesimal variations in the speed and intensity of invisible and intangible stimuli, it will not be difficult to conceive the variations of brain patterns which render possible the specific responses to the coarser contacts of visible environment.

Each brain pattern is adapted for but one type of motion, and so the specific stimuli of the innumerable ceptors play each upon their own brain patterns only. In addition, each brain pattern can react to stimuli applied only within certain limits. Too bright a light blinds; too loud a sound deafens. No mechanism is adapted for waves of light above or below a certain rate of speed, although this range varies in different individuals and in different species according to the training of the individual and the need of the species.

We have already referred to the fact that there is no receptive mechanism adapted to the stimuli from the X-ray, from the high-speed bullet, from electricity. So, too, there are innumerable forces in nature which can excite in man no adaptive response, since there exist in man no brain patterns tuned to their waves, as in the case of certain ethereal and radioactive forces.

On this mechanistic basis the emotions may be explained as activations of the entire motor mechanism for fighting, for escaping, for copulating. The sight of an enemy stimulates in the brain those patterns formed by the previous experiences of the individual with that enemy, and also the experiences of the race whenever an enemy had to be met and overcome. These many brain patterns in turn activate each that part of the body through which lies the path of its own adaptive response—those parts including the special energizing or activating organs. Laboratory experiments show that in an animal driven strongly by emotion the following changes may be seen: (1) a mobilization of the energy-giving compound in the brain cells, evidenced by a primary increase of the Nissl substance and a later disappearance of this substance and the deterioration of the cells; (2) increased output of epinephrin, of thyroid secretion, of glycogen and an increase of the power of oxidation in the muscles; (3) accelerated circulation and respiration with increased body temperature; (4) altered metabolism. All of these are adaptations to increase the motor efficiency of the mechanism. In addition we find an inhibition of the functions of every organ and tissue that consumes energy, but does not contribute directly to motor efficiency. The mouth becomes dry; the gastric and pancreatic secretions are lessened or are completely inhibited; peristaltic action stops. The obvious purpose of all these activations and inhibitions is to mass every atom of energy upon the muscles that are conducting the defense or attack.

So strong is the influence of phylogenetic experience that though an enemy today may not be met by actual physical attack, yet the decks are cleared for action, as it were, and the weapons made ready, the body as a result being shaken and ex-

hausted. The type of emotion is plainly declared by the activation of the muscles which would be used if the appropriate physical action were consummated. In anger the teeth are set, the fists are clenched, the posture is rigid; in fear the muscles collapse, the joints tremble and the running mechanism is activated for flight; in sexual excitement the mimicry is as obvious. The emotions, then, are the preparations for phylogenetic activities. If the activities are consummated, the fuel —glycogen—and the activating secretions from the thyroid, the adrenals, the hypophysis are consumed. In the activation without action, these products must be eliminated as waste products and so a heavy strain is put upon the organs of elimination. It is obvious that the body under emotion might be clarified by active muscular exercise, but the subject of the emotion is so strongly integrated thereby that it is difficult for him to engage in diverting, clarifying exertion. The person in anger does not want to be saved from the ill-effects of his own emotion; he wants only to fight; the person in fear wants only to escape; the person under sexual excitement wants only possession.

All the lesser emotions—worry, jealousy, envy, grief, disappointment, expectation—all these influence the body in this manner, the consequences depending upon the intensity of the emotion and its protraction. Chronic emotional stimulation, therefore, may fatigue or exhaust the brain and may cause cardiovascular disease, indigestion, Graves's disease, diabetes, and insanity even.

The effect of the emotions upon the body mechanism may be compared to that produced upon the mechanism of an automobile if its engines are kept running at full speed while the machine is stationary. The whole machine will be shaken and weakened, the batteries and weakest parts being the first to become impaired and destroyed, the length of usefulness of the automobile being correspondingly limited.

We have shown that the effects upon the bodily mechanism of the action of the various ceptors is in relation to the response made by the *brain* to the stimuli received. What is this power of response on the part of the brain but *consciousness?* If this is so, then consciousness itself is a reaction to environment, and its intensity must vary with the state of the brain and with the environmental stimuli. If the brain cells are in the state of highest efficiency, if their energy has not been drawn upon, then consciousness is at its height; if the brain is fatigued, that is, if the energy stored in the cells has been exhausted to any degree, then the intensity of consciousness is diminished. So degrees of consciousness vary from the height maintained by cells in full vigor through the stages of fatigue to sleep, to the deeper unconsciousness secured by the administration of inhalation anesthetics, to that complete unconsciousness of the environment which is secured by blocking the advent to the brain of all impressions from both distance and contact ceptors, by the use of both local and inhalation anesthetics —the state of anoci-association.

Animals and man may be so exhausted as to be only semi-conscious. While a brain perfectly refreshed by a long sleep can not immediately sleep again, the exhausted brain and the refreshed brain when subjected to equal stimuli will rise to unequal heights of consciousness. The nature of the physical basis of consciousness has been sought in experiments on rabbits which were kept awake from 100 to 109 hours. At the end of this time they were in a state of extreme exhaustion and seemed semi-conscious. If the wakefulness had been further prolonged, this state of semi-con-

sciousness would have steadily changed until it culminated in the permanent unconsciousness of death. An examination of the brain cells of these animals showed physical changes identical with those produced by exhaustion from other causes, such as prolonged physical exertion or emotional strain. After 100 hours of wakefulness the rabbits were allowed a long period of sleep. All the brain cells were restored except those that had been in a state of complete exhaustion. A single seance of sleep served to restore some of the cells, but those which had undergone extreme changes required very prolonged rest. These experiments give us a definite physical basis for explaining the cost to the body mechanism of maintaining the conscious state. We have stated that the brain cell changes produced by prolonged consciousness are identical with those produced by physical exertion and by emotional strain. Rest, then, and especially sleep, is needed to restore the physical state of the brain cells which have been impaired, and as the brain cells constitute the central battery of the body mechanism, their restoration is essential for the maintenance of normal vitality.

In ordinary parlance, by consciousness we mean the activity of that part of the brain in which associative memory resides, but while associative memory is suspended the activities of the brain as a whole are by no means suspended; the respiratory and circulatory centers are active, as are those centers which maintain muscular tone. This is shown by the muscular response to external stimuli made by the normal person in sleep; by the occasional activation of motor patterns which may break through into consciousness causing dreams; and finally by the responses of the motor mechanism made to the injuring stimuli of an operation on a patient under inhalation anesthesia only.

Direct proof of the mechanistic action of many of life's phenomena is lacking, but the proof is definite and final of the part that the brain cells play in maintaining consciousness; of the fact that the degree of consciousness and mental efficiency depends upon the physical state of the brain cells; and finally that efficiency may be restored by sleep, provided that exhaustion of the cells has not progressed too far. In this greatest phenomenon of life, then, the mechanistic theory is in harmony with the facts.

Perhaps no more convincing proof of our thesis that the body is a mechanism developed and adapted to its purposes by environment can be secured than by a study of that most constant manifestation of consciousness—pain.

Like the other phenomena of life, pain was undoubtedly evolved for a particular purpose—surely for the good of the individual. Like fear and worry, it frequently is injurious. What then may be its purpose?

We postulate that pain is a result of contact ceptor stimulation for the purpose of securing protective muscular activity. This postulate applies to all kinds of pain, whatever their cause—whether physical injury, pyogenic infection, the obstruction of hollow viscera, childbirth, etc.

All forms of pain are associated with muscular action, and as in every other stimulation of the ceptors, each kind of pain is specific to the causative stimuli. The child puts his hand in the fire; physical injury pain results and the appropriate muscular response is elicited. If pressure is prolonged on some parts of the body, anemia of the parts may result, with a corresponding discomfort or pain, requiring muscular action for relief. When the rays

of the sun strike directly upon the retina, light pain causes an immediate protective action; so too in the evacuation of the intestine and the urinary bladder as normal acts, and in overcoming obstruction of these tracts, discomfort or pain compel the required muscular actions. This view of pain as a stimulation to motor action explains why only certain types of infection are associated with pain; namely, those types in which the infection may be spread by muscular action or those in which the fixation of parts by continued muscular rigidity is an advantage. As a further remarkable proof of the marvelous adaptation of the body mechanism to meet varying environmental conditions, we find that just as nociceptors have been implanted in those parts of the body only which have been subject to nocuous contacts, so a type of infection which causes muscular action in one part of the body may cause none when it attacks another.

This postulate gives us the key to the pain-muscular phenomena of peritonitis, pleurisy, cystitis, cholecystitis, etc., as well as to the pain-muscular phenomena in obstructions of the hollow viscera. If pain is a part of a muscular response and occurs only as a result of contact ceptor stimulation by physical injury, infection, anemia, or obstruction, we may well inquire which part of the nerve mechanism is the site of the phenomenon of pain. Is it the nerve ending, the nerve trunk, or the brain? That is, is pain associated with the physical contact with the nerve ending, or with the physical act of transmission along the nerve trunk, or with the change of brain cell substance by means of which the motor-producing energy is released?

We postulate that the pain is associated with the discharge of energy from the brain cells. If this is true, then if every nociceptor in the body were equally stimulated in such a manner that all the stimuli should reach the brain cells simultaneously, then the cells would find themselves in equilibrium and no motor act would be performed. But if all the pain nerve ceptors but one were equally stimulated, and this one more strongly stimulated than the rest, then this one would gain possession of the final common path—would cause a muscular action and the sensation of pain.

It is well known that when a greater pain or stimulus is thrown into competition with a lesser one, the lesser is submerged. Of this fact the schoolboy makes use when he initiates the novice into the mystery of the painless pulling of hair. The simultaneous but severe application of the boot to the blindfolded victim takes complete but exclusive possession of the final common path and the hair is painlessly plucked as a result of the triumph of the boot stimulus over the pull on the hair in the struggle for the final common path.

Persons who have survived a sudden, complete exposure to superheated steam, or whose bodies have been enwrapped in flame, testify that they have felt no pain. As this absence of pain may be due to the fact that the emotion of fear gained the final common path, to the exclusion of all other stimuli, we are trying by experimentation to discover the effects of simultaneous painful stimulation of all parts of the body. The data already in hand, and the experiments now in progress, in which anesthetized animals are subjected to powerful stimuli applied to certain parts of the body only, or simultaneously to all parts of the body, lead us to believe that in the former case the brain cells become stimulated or hyperchromatic, while in the latter case no brain cell changes occur. We believe that our experiments will prove that an equal and simultaneous stimula-

tion of all parts of the body leaves the brain cells in a state of equilibrium. Our theory of pain will then be well sustained, not only by common observation, but by experimental proof, and so the mechanistic view will be found in complete harmony with another important reaction.

We have stated that when a number of contact stimuli act simultaneously, the strongest stimulus will gain possession of the final common path—the path of action. When, however, stimuli of the distance ceptors compete with stimuli of the contact ceptors, the contact-ceptor stimuli often secure the common path, not because they are stronger or more important, but because they are immediate and urgent. In many instances, however, the distance-ceptor stimuli are strong, have the advantage of a lowered threshold, and therefore compete successfully with the immediate and present stimuli of the contact ceptors. In such cases we have the interesting phenomenon of physical injury without resultant pain or muscular response. The distance ceptor stimuli which may thus triumph over even powerful contact-ceptor stimuli are those causing strong emotions—as great anger in fighting; great fear in a battle; intense sexual excitement. Dr. Livingstone has testified to his complete unconsciousness to pain during his struggle with a lion; although he was torn by teeth and claws, his fear overcame all other impressions. By frequently repeated stimulation the Dervish secures a low threshold to the emotions caused by the thought of God or the devil and his emotional excitement is increased by the presence of others under the same stimulation; emotion, therefore, secures the final common path and he is unconscious of pain when he lashes, cuts and bruises his body. The phenomena of hysteria may be explained on this basis, as may the unconsciousness of passing events in a person in the midst of a great and overwhelming grief. By constant practise the student may secure the final common path for such impressions as are derived from the stimuli offered by the subject of his study, and so he will be oblivious of his surroundings. Concentration is but another name for a final common path secured by the repetition and summation of certain stimuli.

If our premises are sustained then we can recognize in man no will, no ego, no possibility for spontaneous action, for every action must be a response to the stimuli of contact or distance ceptors, or to their recall through associative memory. Memory is awakened by symbols which represent any of the objects or forces associated with the act recalled. Spoken and written words, pictures, sounds, may stimulate the brain patterns formed by previous stimulation of the distance ceptors; while touch, pain, temperature, pressure, may recall previous contact-ceptor stimuli. Memory depends in part upon the adequacy of the symbol, and in part upon the state of the threshold. If one has ever been attacked by a snake, the threshold to any symbol which could recall that attack would be low; the later recall of anything associated with the bite or its results would produce in memory a recapitulation of the whole scene, while even harmless snakes would thereafter be greeted with a shudder. On the other hand, in a child the threshold is low to the desire for the possession of any new and strange object; in a child, therefore, to whom a snake is merely an unusual and fascinating object, there is aroused only curiosity and the desire for the possession of a new plaything.

If we are to attribute to man the possession of a governing attribute, not possessed by other parts of the animal creation,

where are we to draw the boundary line, and say "here the ego—the will—the reason—emerges"? What attribute, after all, has man which in its ultimate analysis is not possessed by the lowest animals or by the vegetable creation, even? From the amœba, on through all the stages of animal existence, every action is but a response to adequate stimulus; and as a result of adequate stimuli each step has been taken toward the higher and more intricate mechanisms which play the higher and more intricate parts in the great scheme of nature.

The Venus fly trap responds to as delicate a stimulus as do any of the contact ceptors of animals, and the motor activity resulting from the stimulus is as complex. To an insect-like touch the plant responds; to a rough contact there is no response; that is, the motor mechanism of the plant has become attuned to only such stimuli as simulate the contact of those insects which form its diet. It catches flies, eats and digests them, and ejects the refuse. The amœba does no less. The frog does no more, excepting that in its place in creation a few more reactions are required for its sustenance and for the propagation of its species. Man does no more, excepting that in man's manifold relations there are innumerable stimuli, for meeting which adequately, innumerable mechanisms have been evolved. The motor mechanism of the fly trap is perfectly adapted to its purpose. The motor mechanism of man is adapted to its manifold uses, and as new environmental influences surround him, we must believe that new adaptations of the mechanism will be evolved to meet the new conditions.

Is not this conception of man's activities infinitely more wonderful, and infinitely more comprehensible than is the conception that his activities may be accounted for by the existence of an unknown, unimaginable, and intangible force called "mind" or "soul"?

We have already shown how the nerve mechanism is so well adapted to the innumerable stimuli of environment that it can accurately transmit and distinguish between the infinite variations of speed in the ether waves producing light, and the air waves producing sound. Each rate of vibration energizes only the mechanism which has been attuned to it. With marvelous accuracy the light and sound waves gain access to the nerve tissue and are finally interpreted in terms of motor responses, each by the brain pattern attuned to that particular speed and intensity. So stimuli and resultant actions multiplied by the total number of the motor patterns in the brain of man give us the sum total of his life's activities—they constitute his life.

As in evolutionary history the permanence of an adaptation of the body mechanism depends upon its value in the preservation of the life of the individual and upon its power to increase the value of the individual to the race, so the importance and truth of these postulates and theories may well be judged on the same basis.

The fundamental instincts of all living matter are self-preservation, and the propagation of the species. The instinct for self-preservation causes a plant to turn away from cold and damaging winds toward the life-giving sun; the inert mussel to withdraw within its shell; the insect to take flight; the animal to fight or to flee; and man to procure food that he may oppose starvation, to shelter himself and to provide clothes that he may avoid the dangers of excessive cold and heat, to combat death from disease by seeking medical aid, to avoid destruction by man or brute by fight or by flight. The instinct to propagate the species leads brute man by crude

methods, and cultured man by methods more refined, to put out of his way sex rivals so that his own life may be continued through offspring. The life of the species is further assured by the protective action exercised over the young by the adults of the species. As soon as the youngest offspring is able successfully to carry on his own struggle with environment there is no longer need for the parent, and the parent enters therefore the stage of disintegration. The average length of life in any species is the sum of the years of immaturity, plus the years of female fertility, plus the adolescent years of the offspring.

The stimuli resulting from these two dominant instincts are now so overpowering as compared with all other environmental stimuli that the mere possession of adequate knowledge of the damaging effects of certain actions as compared with the saving effects of others will (other things being equal) lead the individual to choose the right,—the self- and species-preservative course of action, instead of the wrong,—the self- and species-destructive course of action.

The dissemination of the knowledge of the far-reaching deleterious effects of protracted emotional strain, of overwork, and of worry will automatically raise man's threshold to the damaging activating stimuli causing the strong emotions, and will cause him to avoid dangerous strains of every kind. The individual thus protected will therefore rise to a plane of poise and efficiency far above that of his uncontrolled fellows, and by so much will his efficiency, health and happiness be augmented.

A full acceptance of this theory can not fail to produce in those in whose charge rests the welfare of the young, an overwhelming desire to surround children with those environmental stimuli only which will tend to their highest ultimate welfare.

Such is the stimulating force of tradition that many who have been educated under the tenets of traditional beliefs will oppose these hypotheses—even violently, it may be. So they have opposed them; so they opposed Darwin; so they have opposed all new and apparently revolutionary doctrines. Yet these persons themselves are by their very actions proving the efficiency of the vital principles which we have enunciated. What is the whole social welfare movement but a recognition on the part of municipalities, educational boards, and religious organizations of the fact that the future welfare of the race depends upon the administration to the young of forceful uplifting environmental stimuli.

There are now, as there were in Darwin's day, many who feel that man is degraded from his high estate by the conception that he is not a reasoning, willing being, the result of a special creation. But one may wonder indeed what conception of the origin of man can be more wonderful or more inspiring than the belief that he has been slowly evolved through the ages, and that all creatures have had a part in his development; that each form of life has contributed and is contributing still to his present welfare and to his future advancement.

RECAPITULATION

Psychology—the science of the human soul and its relations—under the mechanistic theory of life, must receive a new definition. It becomes a science of man's activities as determined by the environmental stimuli of his phylogeny and of his ontogeny.

On this basis we postulate that throughout the history of the race nothing has been lost, but that every experience of the race and of the individual has been retained for the guidance of the individual and of the race; that for the accomplishment of this

end, there has been evolved through the ages a nerve mechanism of such infinite delicacy and precision that in some unknown manner it can register permanently within itself every impression received in the phylogenetic and ontogenetic experience of the individual; that each of these nerve mechanisms or brain patterns has its own connection with the external world, and that each is attuned to receive impressions of but one kind, as in the apparatus of wireless telegraphy each instrument can receive and interpret waves of a certain rate of intensity only; that thought, will, ego, personality, perception, imagination, reason, emotion, choice, memory, are to be interpreted in terms of these brain patterns; that these so-called phenomena of human life depend upon the stimuli which can secure the final common path, this in turn having been determined by the frequency and the strength of the environmental stimuli of the past and of the present.

Finally, as for life's origin and life's ultimate end, we are content to say that they are unknown, perhaps unknowable. We know only that living matter, like lifeless matter, has its own place in the cosmic processes; that the gigantic forces which operated to produce a world upon which life could exist, as a logical sequence, when the time was ripe, evolved life; and finally that these cosmic forces are still active, though none can tell what worlds and what races may be the result of their coming activities.

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THE CHESTNUT-BLIGHT PARASITE (ENDOTHIA PARASITICA) FROM CHINA

IN common with Dr. Metcalf[1] and some other pathologists the writers have believed in the foreign origin of the chestnut-blight and its causal organism.

Having first proved by thorough investigation[2] that the species of *Endothia* (*E. radicalis* (Schw.) De Not.) common on the chestnut in southern Europe is not an active parasite and is morphologically distinct from *E. parasitica* our attention was again turned to the orient. Previous efforts to get *Endothia* by correspondence from China and Japan have been fruitless.

Knowing Mr. Meyer's keenness of observation and facilities for examining chestnuts in China, it occurred to us to try to enlist his services in the search for the fungus. We took up the matter with Mr. Fairchild early in February, 1913. He heartily approved of the proposition and data were prepared and sent to Mr. Meyer. On June 28, as Mr. Fairchild has related, a letter was received from Mr. Meyer enclosing a small specimen of diseased chestnut bark collected June 3, 1913, near San tun ying, Chili Province, China. This specimen showed the characteristic mycelial "fans" in the bark and a few pycnidia which agreed exactly in macroscopic and microscopic characters with *Endothia parasitica*. Meyer's description of the disease on these Chinese chestnut trees (whose specific determination is still under investigation) also agreed with the behavior of the disease on some oriental chestnut trees in this country.

Cultures on cornmeal were made June 30 from the mycelium and from pycnospores from Meyer's specimen. The cultures from mycelium did not grow, but three of the four cultures made from pycnospores developed normally and appeared pure. Cultures of *Endothia parasitica* from American material were also made at the same time on the same medium for comparison. The development of the Chinese fungus was in all cases indistinguishable from that of American origin. The amount of growth, the color and character of the mycelium, time of appearance, abundance and distribution of pycnidia were so similar that it was impossible to tell the cultures

[1] Bur. Plant Ind., U. S. Dept. Agr., Bull. 121, pt. 6, 1908; also *Trans. Mass. Hort. Soc.*, 1912, pt. 1, pp. 69–95.

[2] C. L. Shear, "*Endothia radicalis* (Schw.)," *Phytopathology*, 3: 61, February, 1913.